LOGICO-MATHEMATICAL PROCESSES

IN BEGINNING READING

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LOGIC-MATHEMATICAL PROCESSES IN BEGINNING READING

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LOGIC-MATHEMATICAL PROCESSES

IN BEGINNING READING

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Deirdre Denise (Cosper) Greer, daughter of Horace Eugene and Melva (Cook) Cosper, was born January 13, 1962, in LaGrange, Georgia. Deirdre has three brothers, Kenneth Eugene Cosper, Gary Alan Cosper, and Jeffery Lane Cosper. She married Richard Joseph Greer, on March 12, 1986, and they have two children, Corey Joseph Greer and Emily Lauren Greer. She attended Columbus State University and graduated summa cum laude with a Bachelor of Science in Early Childhood Education in June, 1997. She was selected as the University's Academic Recognition Day Representative for outstanding academic achievement. She received a Master of Education degree in Early Childhood Education from Columbus State University in June 2001. She worked as a third and first grade teacher for eight years in the Muscogee County School District, Columbus, Georgia. She was selected as the Teacher of the Year representative for her school for the 2000-2001 school year. She was recognized as an outstanding alumna by Columbus State University for the 2003-2004 school year. She entered graduate school, Auburn University, in August 2003 to pursue a Doctor of Philosophy degree in Early Childhood Education.

DISSERTATION ABSTRACT

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IN BEGINNING READING

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Phonemic awareness has been shown to be a foundational component that initiates children's insight into the alphabetic principle. With the support of research, programs have been developed for children at the preschool level that are designed to enhance their phonemic awareness in order to better prepare them for learning to read. An important body of research that has not been considered in the development of reading programs is that which shows how children understand written language in the years leading up to their entering school. It is this research along with Piaget's theory of cognitive development, upon which it is based, that can inform educators as they continue to improve reading instruction. The present study showed that in order to effectively utilize phonemic awareness as a component of beginning reading children must be able to understand the relationships between letters and words. The development of the understanding of these relationships occurs at about the same time as an area of logico-mathematical knowledge identified by Piaget as the part-whole relationship. Thirty-nine children, 5- 10- years old, were administered The Dynamic Indicators of Basic Early Literacy Skills™ Phoneme Segmentation Fluency task and Nonsense Word Fluency task. Two Piagetian part-whole reasoning tasks and 2 researcher-created tasks were also administered. The researcher-created tasks included a word sorting task and a letter sorting task and examined various criteria used by the subjects for classification. Chi square analyses of phoneme segmentation fluency (PSF) with age and nonsense word fluency (NWF) with age showed that phonemic awareness follows a developmental progression. Connections to Piaget's descriptions of developmental behaviors were also described. Regression analyses between PSF and part-whole reasoning and NWF and part-whole reasoning showed that the development of phonemic awareness occurs in conjunction with the development of part-whole reasoning. Multiple regression analyses with PSF and several logico-mathematical constructs (classification, part-whole reasoning, and class inclusion) and NWF and the logico-mathematical constructs showed that the development of phonemic awareness is a logico-mathematical process.

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Introduction

Phonemic awareness is currently receiving a heavy emphasis in early reading instruction. Children as young as four- and five-years-old are being trained to identify letter sounds, segment the sounds found in words, and blend those sounds back together to pronounce words. This relationship of letters to words is one of parts comprising a whole, and the instructional process is similar to that of the logico-mathematical development of part-whole relationships. It would follow that in order for conceptual development of reading to occur, a child would need to have developed the logico-mathematical processes of classification and part-whole reasoning. Instructional methods that are being used with young children have been shown to be successful in training children to begin reading at a young age, but at what price?

The purpose of this study is to expand current reading theories driving beginning reading instruction by merging them with cognitive learning theories in order to examine phonemic awareness as a developmental process that develops in conjunction with part-whole reasoning and to determine whether there is a relationship between beginning reading and logico-mathematical processes.

The recent publication of the National Reading Panel (NRP) Report (2000) has played a major role in changing the way reading is being taught in the primary grades. Based on a compilation of experimental research, the report was directed toward finding the most effective methods for beginning reading instruction. One component of reading instruction that was investigated was phonemic awareness. Phonemic awareness was defined as “the ability to focus on and manipulate phonemes in spoken words” (NRP, 2000, p. 2-10). Current instructional methods in preschool and kindergarten focus on the development of this ability largely due to the fact that research has shown that the presence of phonemic awareness combined with letter knowledge can be a strong predictor of how well children will learn to read (NRP, 2000). The development of instruction has therefore been based on the desire to advance children’s phonemic awareness in order to increase the likelihood of their successfully learning to read in the primary grades.

The NRP Report (2000) includes a brief account that alludes to a developmental quality of phonemic awareness, stating that, “it is important to recognize that children will differ in their phonemic awareness” (p. 2-43). The report further elaborates that some students will not develop full phonemic awareness even by second grade. Additionally, longitudinal studies have been conducted in which phonemic awareness and phonics instruction have been used to improve the reading abilities of kindergarten through second grade students. While these programs appear to have been successful in producing differential gains in reading, follow-up studies show that by third grade, normally developing students demonstrate approximately equal levels of reading achievement regardless of the type of early instruction they received (NRP, 2000).

The acknowledgement of these variances in the acquisition of reading skills suggests that a developmental process is involved in the acquisition of phonemic awareness, which would account for “the fact that even though children receive the same instruction, they still differ in how quickly they learn what they are taught," as declared by the National Reading Panel (2000, p. 2-126).

Several phonemic awareness tasks are typically the focus of beginning reading instruction. These tasks include phoneme isolation, phoneme identity, phoneme categorization, phoneme blending, phoneme segmentation, and phoneme deletion. Phoneme isolation requires students to identify individual sounds in words. Phoneme identity involves recognizing common sounds in different words. Phoneme categorization requires students to recognize the word that has a different sound in a sequence of words. In phoneme blending students listen to a sequence of sounds and blend them together to form a word. Phoneme segmentation is the breaking apart of a word into its individual sounds. Finally, phoneme deletion requires students to recognize a word that remains after a specific phoneme is removed from the word. Instruction in these tasks is the initial step toward word reading.

The importance of phonemic awareness and phonemic awareness instruction is not supported wholeheartedly by reading researchers and professionals. Krashen (2004) argues that a review of pure phonemic awareness studies produces small effect sizes indicating that phonemic awareness is not as important to later successful reading as the NRP suggests. However, the fact that classroom instruction is incorporating the use of phonemic awareness training for beginning reading instruction makes it important to continue to investigate the processes involved in the acquisition and application of phonemic awareness knowledge in learning to read.

An additional consideration for beginning reading instruction is the developmental perspective. Strickland and Shanahan (2004) report that the National

Early Literacy Panel (NELP), which was formed to provide a synthesis of research similar to that of the NRP, focused on early literacy development in children from birth to age 5. The report of the NELP found correlations between reading success and phonemic awareness and alphabetic knowledge as did the NRP. However, the report of the NELP also indicated a significant correlation between other factors and success in learning to read. Among these factors are print knowledge, environmental print, invented spelling, listening comprehension, oral language, and vocabulary. Many of these kinds of knowledge are expected to be developed prior to the beginning of formal schooling within the less formal environment of the home through daily interactions or in a preschool environment. In this way literacy education is seen as a natural process that is acquired through meaningful and creative experiences with books and reading and writing activities. Certainly, those beginning understandings that are typically developed during the preschool years are essential to the concepts to be learned once formal schooling begins.

In addition, knowledge of theories of child development is essential as teachers begin the process of formal instruction. Piaget's theory of cognitive development allows teachers to understand the stages and developmental expectations that are applicable to young children. More so than matching children's development to age norms, Piaget's theory provides a framework that helps teachers understand the complex interaction between development and learning (Meier, 2000).

Reading and Development

Research has attempted to connect reading with Piaget's theory of cognitive development (Elkind & Deblinger, 1969; Elkind, Larson, & Van Doorninch, 1965). Just as some reading research has shown the predictive ability of phonemic awareness, research in developmental psychology confirms the construction of knowledge as a developmental process, less dependent on age and more dependent on the quality and quantity of the experiences of the child. In an attempt to connect development and reading Elkind (1981) identified 4 stages in the development of reading.

Elkind's (1981) first stage is the "global undifferentiated stage". This stage, according to Elkind, is characterized by the child's utilization of preconcepts and preseriation. Preconcepts refer to the first concepts used by young children and are characterized by their action orientation, their close association with mental images, and their concrete nature. Due to these preoperational structures young children are unable to perform the necessary classifications and seriations that Elkind attributes to accomplishment in constructing letters, words, and even comprehension. Rather, at this stage the child's knowledge of letters and words is very global with little differentiation, knowing some letters sometimes but not at other times. The rote learning of the order of the alphabet, according to Elkind, is not a true seriation, which requires the ability to say the letters backwards. Attainment of letter and word knowledge at this stage is limited to an acquaintance with letters and words, which is analogous to rote memorization, rather than conceptual knowledge.

Identity decoding is the second stage of reading development identified by Elkind (1981). As children's classification, seriation, and transformation abilities develop, so does their reading development, provided they have opportunities to practice on reading materials. Through activities that allow letter manipulation and printing children develop conceptual understandings of letters and words along with a more differentiated understanding of the unique characteristics of different letters and words. A single sound for each letter is the typical characteristic of this stage.

Equivalence decoding is the next stage of reading development and it coincides with the attainment of concrete operations (Elkind, 1981). Elkind attributes the distinction of multiple sounds for letters to this stage due to the development of logical addition and logical multiplication. For example, the letter *a* has three distinct sounds, /a/, /A/, and /ä/. Elkind describes each letter as a class with their multiple sounds constituting subclasses such that being able to organize more than one sound for a letter becomes logical addition. He further extrapolates that sounds for letter combinations like diphthongs correspond to logical multiplication. For example, the class *ow* consists of the subclasses /o/, /w/, and /ow/. These same processes are then extended to the word level.

The final stage identified by Elkind (1981) is automatization and externalization. This is the stage whereby decoding has become automatic and attention is focused on comprehension.

Elkind's delineation of stages of reading has not been without criticism (Gallagher, 1979; Zimiles, 1981). Elkind (1981) admits that the ideas that he developed by examining the logical substructure of reading have not been verified experimentally. Zimiles points out that sounds are in fact functions of letters rather than attributes as understood by Elkind. Zimiles contends that it is not the fact that the preoperational child cannot consider multiple sounds of a letter at the same time that makes the process of reading difficult, but that the child is being asked to consider the function of a symbol. In fact, the child must consider multiple functions of multiple symbols in order to coordinate the process of reading. So, while Zimiles disagrees with Elkind that multiplicative reasoning is required for the decoding process, he does agree that decoding requires the integration of multiple intellectual accomplishments.

Gallagher (1979), also critical of Elkind's (1981) stages of reading development, urged a focus on Piaget's biological model, or the process of equilibration. Gallagher referred to the mechanism of phenocopy in which organisms adapt to a new outside environment organically. Adaptation is a kind of self-regulation. This biological mechanism is analogous to the process of equilibration, which occurs as children construct new understandings of concepts through a reordering. During the process of equilibration a child's interactions with the environment are assimilated and accommodated into the developing structures such that there is a balance between the two processes. This balance ensures that schemata are sufficiently developed so that similarities and differences are detected (Wadsworth, 1996).

Gallagher's (1979) criticism of Elkind's research began with his premises that good readers schematize letters and words on a page, and that reading can be improved by nonverbal perceptual training. Gallagher pointed out that to begin to consider the child's reading development one must begin with what the child knows. In this case it is language. She therefore concluded that the structural base for reading is linguistics. In considering the research of Elkind and Deblinger (1969) and Elkind, Larson, and Van Doorninch (1965), Gallagher asserted that Piaget's theory attempts to explain how children move from a focus on perception to conceptual understanding as they construct knowledge. Gallagher emphasizes the fact that psycholinguistics does not ascribe to reading as a precise perceptual process. Adams (1994) however, has more recently shown that good readers attend to nearly each letter and each word in printed text. With more understanding about the way children begin to construct meaning from text, perhaps it is time for further investigation into the connection between beginning reading and cognitive development.

Gallagher's (1979) next point of contention with Elkind and Deblinger (1969) and Elkind, Larson, and Van Doorninch (1965) was their conclusion that concrete operations are the foundation of beginning reading success. She stated the Piagetian principle that language is not sufficient for attaining logico-mathematical operations. Certainly, as Gallagher states, structures connected with conservation have roots prior to the development of language. However, in discussing the role of language in the development of the semiotic function, Piaget and Inhelder (1969) say that language has its own logic and may be a crucial factor in learning logic. This statement is confirmed by delayed emergence of logic in deaf-mutes and blind children. Piaget often finds that development of one structure is "necessary, but not sufficient" for some other structure. Perhaps this relationship exists between language and logico-mathematical operations.

Despite Gallagher's (1979) criticism, she identified reasons to search for a connection between reading and Piagetian theory. However, she suggested that such research concentrate on the relationships between early, fluent readers and organizational tasks based on transitivity. This previous research and its criticism posit ideas that have not led to any decisive findings; however, its importance in suggesting that the role of cognitive development in learning to read is significant. Current research and theory have focused most heavily on identifying the multiple components that contribute to learning to read. One theory that seems to be foundational for much of the current research that is supported by the NRP (2000) is that of Ehri (1991). Equally foundational, though not accepted by the NRP is the naturalistic developmental research of Ferreiro and Teberosky (1982). The research of Ferreiro and Teberosky is based on qualitative and descriptive research methods and the theory of Piaget, but it does not meet the criteria set forth by the NRP for inclusion into their study. The NRP only looked at moderate to high quality experimental and quasi-experimental studies that sufficiently represented the population so that the Panel's claims of effectiveness would be substantiated. Although the research of Ferreiro and Teberosky is not a part of the NRP Report, parallels can be drawn between their findings and Ehri's theory on how children develop the ability to read words.

Ehri (1991) identified three phases that characterize the ways children approach reading words; the logographic phase, alphabetic phase, and orthographic phase. Each phase is progressively more complex than the preceding phase.

In the logographic phase children attend to visual characteristics of words and do not use the letters themselves as cues. This attention to the visual appearance of the word is compared with the Chinese use of logographic symbols, which are processed as a whole. According to Ehri (1991) children in the logographic phase of word reading do not attend to the word as a whole; rather they select a salient feature of the word that is associated with the word in memory. For example, the word *look* may be thought of as having two eyes in the middle. This phase also incorporates the "reading" of familiar advertising logos such as Pepsi® with its familiar color pattern. This method proves to be inefficient because many words do not include a prominent visual feature and many words contain visual features that make them indistinguishable from other words. Some children are able to "read" in this manner prior to entering school. As stated by Ehri, one of the significant features of this phase of word recognition is a lack of attention to the letters. Consequently, phonemic awareness is not necessary for the logographic reader.

This phase of word recognition can be placed within the structural framework of constructivist theory. Three characteristics that are specific to the preoperational period indicate that logographic reading is the first stage of a developmental progression in word reading. During the preoperational stage of development children's thought processes are directed by perception. Children at this level attach meaning to an object based on its appearance. This idea is confirmed by the research of Ferreiro and Teberosky (1982) in which they found that children who have not yet begun formal schooling consider the length of a word to be significant in thinking about the size of the object that the word names. They have found that young children often view words as substitutes for objects that are expected to have the characteristics of the objects themselves. This results in the idea that there is a figurative correspondence between the word and the object that it refers to. The development of symbolic function, or the ability to represent something "by means of a 'signifier'" (Piaget & Inhelder, 1969), also occurs during the preoperational period. Clearly, a graphic representation serves as a signifier, though not in the same way for a young child as it does for someone who is able to read. Thirdly, preoperational thought is characterized by centration, or the act of attending to only one salient characteristic of an object. This quality of preoperational thought corresponds with the idea that children in the logographic phase of word recognition attend only to a portion of the word. That is, a portion that for the child is representative of what that word signifies.

Ehri's (1991) next phase of word recognition is the alphabetic phase. This phase is subdivided into partial alphabetic and full alphabetic decoding. Partial alphabetic decoding involves the use of some of the letters of a word, typically the initial or initial and final letters, to develop partial sound correspondences. This phase is sometimes referred to as phonetic cue reading and is contrasted with logographic reading. Ehri says that logographic reading creates an arbitrary access route to meaning in memory whereas phonetic cue reading provides an elementary alphabetic access. Characteristic of this intermediate phase is an inconsistent ability to read the same words in repeated trials confirming that the use of partial letter-sound cues does not provide reliable access to one word exclusive of all others. In the full alphabetic phase however, the child incorporates letter-sound correspondences for the entire word, which may result in slow decoding initially, but provides a more reliable access route for many words (Ehri & McCormick, 1998).

Again, the research of Ferreiro and Teberosky (1982) can provide a connection to constructivist theory. In a word reading task in which children were shown cards depicting both a picture and a word, the children were asked to first identify where there was something to read on the page and secondly, to read what was printed on the card. Four basic response types were identified. The first response type indicated an inability to differentiate between the picture and the print. The second response type showed differentiation, but identification of the print was speculated from the picture. The print was considered to be a label for the picture or at a more advanced level, a sentence that could be associated with the picture. At this level there was no indication of attention to the structure of the print. Children exhibiting the third level of response, however, were beginning to show an initial consideration of the graphic properties of the print. At this level the rudimentary attention to graphic properties is not yet at the letter level, but pertains to the presence of two lines of print as opposed to one line. There is still the idea that the print is a label for the picture but with the added component of some necessity for connecting that label to the graphic presentation of the print. At response level four, the attention to the graphic elements of the print becomes more refined such that there is a correspondence between the sound segments of language and the graphic segments that are printed. At first this correspondence is a syllabic separation of the language to visual separation of the graphic representation. For example, three words might be read as a three syllable utterance. Later in development there is an association with some letters. This progression illustrates children's gradually increasing attention to the more intricate features of words very much like that described by Ehri (1991) as children move toward full alphabetic processing and an efficient method of identifying words.

The final and most efficient phase of word recognition defined by Ehri (1991) is the orthographic phase. This phase is characterized by the child's increased knowledge of spelling patterns, which enables him to process words more efficiently by recognizing groups of letters as a single unit rather than one letter at a time. This process results in reading many words by analogy to known words. Ferreiro and Teberosky's (1982) research does not provide any illustration of this phase of word reading because they worked with students prior to formal schooling.

While Ehri's (1991) description of the development of word reading ability in children is delineated in a developmental progression, she is adamant in her use of the word "phases" as opposed to stages in discussing this progression. She asserts that this precision in terminology is an attempt to "limit presumptions about developmental relationships among the phases" (p. 384). Regardless of Ehri's reluctance to refer to the developmental progression of word recognition, it is clear through the comparison of Ehri's research with the research of Piaget and Inhelder (1969), along with that of Ferreiro and Teberosky (1982) that children attend to words initially in a specific way that is then gradually altered by the child's experiences with print. The fact that children who lack experiences with text have less knowledge than their same age peers about how print works but older children with little experience with print demonstrate the same types of development as younger children who have had more experiences with print, indicates that there is a relationship between the phases.

Piaget does not directly address the issue of reading; however, Piagetian theory does address the fact that learning is a result of a learner's assimilation of information into schemes that are present in each individual and not of the imposition of a method of instruction onto a learner. That is, learning is a result of how the learner acts on new information (Ferreiro & Teberosky, 1982), not what an adult attempts to teach, or transmit, to the learner. It is this characteristic of learning that accounts for the individual differences in the learning of what is taught. Also of significance in considering what students are able to learn, is their individual level of cognitive development.

Piaget divided knowledge into three basic areas, logico-mathematical, physical, and social. His work in the area of logico-mathematical reasoning has been typically applied to the development of mathematics (Kamii, 1994); yet reasoning in all areas is greatly affected by these processes. Logico-mathematical knowledge consists of the relationships constructed between objects, people, and ideas. These constructed relationships may vary among individual children. For example, when presented with 2 buttons, one red and one blue, one child may say they are the same because they are both buttons. Another child may say the buttons are different because one is red and one is blue. These types of relationships are constructed internally through experiences with objects, people, and ideas. Experiences with print must therefore involve the construction of logico-mathematical knowledge. The evidence for the involvement of logico-mathematical knowledge in beginning reading can be seen in the work of Ehri (1991) and Ferreiro and Teberosky (1982).

Webster and Ammon (1994) have connected reading and writing with the development of concrete operations, of which logico-mathematical operations are a part. This study explored the relationship between specific seriation and classification tasks and specific reading and writing tasks. Participants of the study were 65 fifth grade students. Piagetian tasks in hierarchical classification, additive seriation of weight, and tactile seriation were administered to the students individually. The researchers constructed their own reading and writing tasks. Students completed a comparison writing task and a narrative writing task. The compositions were scored according to how well they were organized. Specifically, the comparative writing scores reflected the degree of hierarchical organization used and the narrative writing was scored based on the students' identification of temporal and causal relationships placed in the proper sequence. For the writing tasks the students were given a passage to read and retell. Scores were reflective of the organization of the students' retelling and were used as a measure of comprehension.

Partial correlations were used to determine specific relationships between concrete operations and writing. Seriation with classification controlled was a better predictor of the children's ability to organize narrative writing than classification with seriation controlled. Similarly, classification with seriation controlled was a better predictor of their ability to organize a comparison than the seriation with classification controlled. The relationship between classification and comparative writing organization was stronger than that between seriation and narrative organization indicating, according to Webster and Ammon (1994), that story writing is less correlated with specific cognitive measures. Chi-square analyses were also performed and showed a clear association between seriation and narrative organization as well as a significant association between classification and comparison organization. Chi-square analyses also showed a non-significant association between seriation and comparative writing organization and a non-significant association between classification and narrative organization. Although some scores deviated from this pattern, the deviations were nearly all in one direction. That is, they scored high on the cognitive measures and low on the writing tasks. Only one student in each category scored low on the cognitive measures and high on the writing tasks. Webster and Ammon interpret this characteristic of the data to indicate that facility with the relevant cognitive skill is necessary but not sufficient for the students to perform well on the writing tasks. Similar results were obtained for the reading tasks with seriation being a better predictor of narrative comprehension and classification being a better predictor of comparative comprehension. Likewise, the relevant cognitive skill was found to be necessary but not sufficient for organized reading recall. It is clear from this investigation that logico-mathematical operations indeed have an impact on reading and writing.

Although this study involved older readers and complex reading tasks, the development of these skills must begin at a less sophisticated level sometime during the beginning processes of learning to read. The process is then gradually refined as the learner has more experiences with print. In this manner, those children who read more become better readers and those who do not read very much fall behind in reading ability. This circumstance has been elaborated by Stanovich (1986) and is referred to as the Matthew effect.

Logico-mathematical reasoning is developed through reflecting abstraction. That is, the child constructs relationships from within based on what he knows and observes as he interacts with the environment. Through interactions, the child assimilates and accommodates information into the developing cognitive structures. At some point in this development, logico-mathematical structures are formed. These structures, although they are new structures, are about old structures (Piaget, 2001). This process of differentiation through reflecting abstraction results in the ability to more acutely discriminate similarities and differences.

One area of logico-mathematical reasoning that appears to be specifically applicable to the development of phonemic awareness is the ability to understand part-whole relationships. While Elkind (1981) identified this operation, along with that of seriation, in his discussion about stages of reading development, more has been learned about the component skills involved in learning to read. It is important to continue to examine these processes within the framework of cognitive development.

Classification, as a structure of logico-mathematical reasoning, involves the identification of similarities and differences among objects. As such, classification appears to be applicable to the process of learning to read. Piaget (1985) recognized four levels in the development of classifications. The first level may involve the use of different criteria for successive objects, resulting in an assortment of objects that are not similar. For example, once an object is selected and a characteristic used to select a second object, a different characteristic of the second object may be used to select the third object and so on. Similarly, objects may be classified together because of a relationship that the child thinks makes them go together. For example, a triangle may be placed on top of a square because it resembles a house. At this level the child does not classify objects according to a static criterion and the resulting collection is referred to as a graphic collection. According to Inhelder and Piaget (1969), a graphic collection is not a true classification. In this respect, the logico-mathematical process of classification is not completely developed at this point. A connection can be made between the way a child begins to classify and Ehri's (1991) logographic phase of reading words. In both classification and logographic reading, the focus of the child's attempts is on the graphic aspect of the tasks.

At the next level of development, there are several possible ways the child may classify objects though the classifications still do not involve complex co-ordinations. Complex co-ordinations consist of two types of properties of objects, intensive properties and extensive properties. Intensive properties are those properties that are common to all the members of a class of objects along with those properties that differentiate the members of a class of objects from members of another class (Inhelder & Piaget, 1969).

Extensive properties are those properties of a class that can be described by the quantifiers “all,” “some,” or “none” in applying that property to the specific class or to other classes to which the object belongs. It is the co-ordination of these intensive and extensive properties that must occur in order for part-whole relations to be realized. Because classifications at this level do not yet involve these complex co-ordinations, a child at this level is likely to form several small groupings of objects with each collection representing a different criterion for grouping. An example of groupings of this type might be a group of red flowers, a group of flowers with many petals, and a group of flowers with a distinct center. At this level the change in criteria is not based on an anticipatory plan, rather it is because the child forgets what went before. A slightly more complex grouping, although at the same level, is the assembly of small groups based on multiple criteria through an anticipatory plan. An example of this type of grouping would be the formation of many small groups each of which contain like objects, such as, a group of circles, a group of squares, a group of the letter *A* s, and a groups of the letter *X* s, as opposed to a group of shapes and a group of letters. As development continues within this level the child may begin to eliminate variations in criterion while maintaining that of a larger grouping. For example, after forming groups of four different colors of a set of shapes the child may then reduce the groupings to that of three different shapes. Finally, groupings are formed that contain subgroups. For example, a collection of different colored shapes might be grouped by shape and within the groups each shape is further grouped by color. The important change that occurs at this level is a gradual co-ordination of the properties of objects in a class and part-whole relations and inclusion (Inhelder & Piaget, 1969).

The gradual co-ordination of properties of objects exhibited at this level exhibits an increasing ability to attend to characteristics of objects. This is similar to what happens as children enter the partial alphabetic phase of word recognition. A single letter first becomes the focus of the child's attention followed gradually by multiple letters. In both classification and word recognition the child is demonstrating an increasing capacity for attending to multiple aspects of objects.

In the third level of the development of classifications the further co-ordination of the intensive and extensive properties of members of classes is seen. This co-ordination results in the further subclasses being realized, yet without the quantification of inclusion (Inhelder & Piaget, 1969). That is, objects are grouped hierarchically yet the child is still unable to then realize that a subclass constitutes a part of the entire class. For example, from a group of animals a child at this level might realize that a group of birds may be formed. When this subclass, birds, is formed it is no longer considered to be a part of the group of animals. This level of classification relates to full alphabetic word recognition. Just as the child is now able to realize more subclasses, he is able to attend to all of the letters in words.

In the final level of development of classifications children are able to perform logical classifications, divide them into subclasses, and quantify inclusions (Piaget, 1985). It is at this final level of development of classifications that part-whole relationships are realizable by the child. The ability to attend to part-whole relationships at this level enables the child to begin to identify common letter clusters that form parts of words. Thus, the orthographic phase of word recognition coincides with this final stage of classificatory development.

Part-whole relationships involve the ability to see simultaneously the existence of a whole group of objects and the individual members that make up that group (Inhelder & Piaget, 1969). According to the developmental framework established by Piaget, the development of part-whole relationships begins to develop in most children around the age of seven or eight, although age alone cannot be considered a guarantee of development. In fact, the development of those children most at risk for having difficulty learning to read is likely to lag behind that of average children due to a lack of experiences which contribute to development. According to Piaget (Flavell, 1963, p. 20), the age at which the attainment of a particular stage of functioning occurs may be affected by a variety of variables including previous experience, intelligence, and culture.

It is this framework that is the basis for the proposed investigation of the development of phonemic awareness in young children as a form of part-whole reasoning in which children must segment the individual letters of a word, produce the individual sounds, and simultaneously put them back together to blend their sounds into a pronounceable word. The assertion of the proposed investigation is that such a task is developmental and that early instructional methods aimed at improving children's phonemic awareness and thus improving the likelihood of their early reading is in effect producing some children who are able to imitate by rote memorization those items that have been "taught" to them without the conceptual understanding that is characteristic of true learning. Studies have shown that although students taught to read by various methods may show impressive gains in achievement with particular methods, overall, by third grade achievement is not significantly better for one method over another (NRP, 2000). This finding suggests that phonemic awareness may be part of a developmental process and that it cannot be effectively "taught" but must be the result of children's internalized actions. When the child is learning in accordance with his developmental level the internal actions on that knowledge allow for conceptual development.

In their discussion of the evolution of children's writing, Ferreiro and Teberosky (1982) noted that among six- and seven-year-olds in their study, those who focused on the number of characters in a word to the exclusion of the order of the characters and vice versa indicated a preoperational level of development. Preoperational children are unable to maintain both of these cognitive functions, number and order of characters, simultaneously as explained by the logico-mathematical construction of part-whole reasoning. Consequently, instruction intended to accomplish tasks of this nature "forces cognitive activity which is beyond their competence" (p. 234).

Given the current emphasis on the early introduction of beginning reading instruction and what is known about how children learn, it follows that there needs to be a closer match between instruction and the learner. As the NRP (2000) stated, "the fact that even though children receive the same instruction, they still differ in how quickly they learn what they are taught" (p.2-126). This statement is indicative of the need to consider the individual learner before beginning instruction that, although it can be "learned," it may not be adequately constructed so that the learner is able to benefit from it. It is in consideration of the varied individual development of children that the proposed research seeks to answer the following questions:

Does phonemic awareness follow a developmental progression?

Does phonemic awareness develop in conjunction with part-whole reasoning?

Is the development of phonemic awareness a logico-mathematical process?

In an effort to answer these questions it is necessary to look at phonemic awareness, which has typically been viewed from a behavioristic perspective, and examine it from a developmental perspective. Such an examination of phonemic awareness involves more than just the determination of whether a child has attained phonemic awareness, but also requires the identification of other processes that may or may not be present in conjunction with phonemic awareness. It is also necessary to examine part-whole reasoning in a way that provides a connection to reading. The present study incorporates part-whole reasoning into beginning reading by making the word the whole with the letters and phonemes as the parts. With this kind of examination it is possible to compare rudimentary part-whole reasoning with its more developed application to reading. Finally, a comparison of those processes used in beginning reading and logico-mathematical reasoning can determine whether a relationship exists between them.

Method

Participants

One hundred forty-four students, 48 from each of the 3 age groups 5- to 6- year-olds, 7- to 8- year-olds, and 9- to 10- year-olds, were randomly selected to be invited to participate in the study. After 10 days a reminder notice was sent to the parents who had not returned the consent form. A total of 68 consent forms were received after 2 weeks. Thirteen participants from each age group were randomly selected using a random number generator for a total of 39 participants. The participants were thirteen 5- to 6-year-olds (*M* = 6.28 years, *SD* = 0.40; 4 girls and 9 boys), thirteen 7- to 8- year-olds (*M* = 7.79 years, *SD* = 0.63; 8 girls and 5 boys), and thirteen 9- to 10- year-olds (*M* = 9.90 years, *SD* = 0.53; 8 girls and 5 boys). The participants were selected from a school in a large school district in the southeastern United States after permission was received from both the selected school district and the selected school. All of the participants were served by the regular education program.

Instruments

Phonemic Awareness. Because phonemic awareness consists of several related processes it was measured through a series of tasks used in the Dynamic Indicators of Basic Early Literacy Skills^{TM} (DIBELS^{TM}) including tasks for assessing students' abilities to: (a) "segment three- and four- phoneme words into their individual phonemes," and (b) "blend letters into words in which letters represent their most common sounds" (Good & Kaminski, 2002).

In the Phoneme Segmentation Fluency task the participants were asked to segment orally presented words consisting of three or four phonemes (See Appendix A). Participants segmented as many words as they could in 1 minute. This task resulted in a number that represented the number of correct phonemes produced in a minute.

In the Nonsense Word Fluency task participants were presented with a page of randomly ordered nonsense words comprised of vowel-consonant and consonant-vowel-consonant patterns (See Appendix B). The participants were asked to produce either the individual letter sounds or the whole word. The result was a number that represented the number of correct letter-sounds produced in a minute.

The scores resulting from these tasks represented two separate levels of phonemic awareness. Nonsense word reading is thought to be a higher level process than phoneme segmentation.

Reliability and validity estimates for DIBELS™ have been computed for its use at the kindergarten and first grade levels. Reliability reports focus on the alternate form reliability of the instrument since it is primarily designed as an ongoing assessment for progress monitoring. Phoneme Segmentation Fluency had a two-week alternate-form reliability of .88 and a one-month alternate-form reliability of .79 at the end of kindergarten. The alternate-form reliability of the Nonsense Word Fluency measure at one month was .83 for the middle of first grade. Split-half reliability for the Phoneme Segmentation Fluency measure was computed at .99 for kindergarten and .83 at first grade (Good & Kaminski, 2002). Reliability statistics for these measures is not provided for older students because its use is primarily intended for kindergarten and first grade except in circumstances where an older student is experiencing difficulty in reading.

For the current study internal consistency was calculated for each measure using Cronbach's alpha. Because the two subtests are mainly intended for kindergarten and first grade students, reliability was checked for each of the three age groups 5- and 6- year-olds (r = 0.88), 7- and 8- year-olds (r = 0.71) , and 9- and 10 – year-olds (r = 0.43). Although the reliability decreases for the older students, it is believed that this is partially due to the fact that children who are better readers rely less on these lower level skills and are therefore less aware of the individual sounds in words. Also, the phonemic awareness skills tested are typically taught in kindergarten and first grade only, therefore these students would be more skilled at identifying the individual phonemes in words.

Concurrent criterion-related validity for DIBELS™ has been established with the Woodcock-Johnson Psycho-Educational Battery-Revised Readiness Cluster. Correlations for Phoneme Segmentation Fluency were .54 in the spring of kindergarten, and for Nonsense Word Fluency in January of first grade the correlations were .36 while in February they were .59. Predictive validity was also computed for each of the measures after one year. Correlations were .68 for Phoneme Segmentation Fluency and .66 for Nonsense Word Fluency. These correlations were also established with the Woodcock-Johnson Psycho-Educational Battery-Revised Readiness Cluster (Good & Kaminski, 2002).

Based on the available information, it is not known whether the reported reliability and validity may differ for groups of children who differ from those in the sample groups. However, for the purposes that the data was used in this study, that is, to determine each subject's level of performance on each phonemic awareness task rather than to monitor student progress and make decisions about their educational programs, the researcher has determined that the test was adequate.

Part-Whole Reasoning. Part-whole reasoning was measured by conducting two Piagetian tasks that identified whether the subject could simultaneously consider a group of objects and a subset of that group. Such part-whole reasoning is a form of logico-mathematical reasoning.

The first task involved presenting five plastic animals, four dogs and one cat. A series of questions and answers were used to confirm that the subject recognized the objects as dogs and a cat. The researcher continued by asking the subject, "Are there more dogs or more animals?" The nature of the task is semi-structured. The researcher must probe further to determine the student's level of understanding. The administration of this task allowed the researcher to determine each subject's level of understanding of part-whole reasoning. In order to quantify this response a value of 0 was assigned if the subject did not understand the concept, a value of 1 was assigned for a vacillating answer, and a value of 2 was assigned if the subject understood the concept given the initial question.

A second task was conducted that involved the researcher presenting the subject with pictures of flowers. There were 8 picture of carnations, 4 of which were pink, the remaining 4 consisted of 1 each of white, yellow, red, and orange. There were also 8 pictures of a variety of other flowers in a variety of colors and 4 pictures of other objects (See Appendix C). The task involved the participants' grouping the pictures and answering questions about the pictures of flowers. Participants were asked a series of questions about the relationships between the flowers and the carnations. Through this questioning, the researcher determined the subject's level of reasoning about part-whole relationships. Quantification was the same as for the previous task, with 0 representing no understanding of the relationships among the flowers, 1 representing a partial or vacillating understanding, and 2 representing a clear understanding of the relationships.

Addressing the reliability and validity of Piagetian tasks is a difficult process. Much of the research that has been conducted using Piaget's developmental assessments has failed to address these issues. Because of this deficiency, it becomes necessary to elucidate an acceptable means of determining the reliability and validity of these measures in the proposed research.

In order to address the issue of reliability, approximately 13 percent (n = 5) of the interviews were viewed and scored by a second party. Agreement was calculated by comparing scores assigned by both raters for each participant's performance on the individual tasks. The first task, part-whole reasoning involving the presentation of plastic animals, resulted in one hundred percent agreement by the two raters. The second Piagetian task, part-whole reasoning with class inclusion involving the presentation of pictures, resulted in sixty percent agreement initially. The two interviews that were rated differently were then viewed by the two raters together. Discussion about the task led to agreement on one of the interviews resulting in a final agreement of eighty percent for the part-whole reasoning with class inclusion task. Concerning the internal consistency reliability, the measure involves only 2 tasks, both of which pose essentially the same question. Cronbach's alpha was calculated using the scores from the 2 tasks (r = .697)

Piaget himself has acknowledged that the children he interviewed answered more in conformity to his theory than those interviewed by another researcher (Piaget, 1997). In an attempt to avoid this crisis, interviews were conducted prior to and separately from the administration of the selected DIBELS™ assessments. In this manner, no conclusions were drawn about the subject's level of functioning apart from that determined by the tasks themselves.

Validation studies have been conducted for some Piagetian tasks. These studies have generally confirmed Piaget's identification of stages of development as indicated by the performance of different ages of children on the tasks. The tasks developed by Piaget have been accepted by many experts in the field of constructivist investigations. According to Flavell (1963), those who dispute the validity are typically those who did not fully understand what Piaget was trying to do.

Two researcher-created tasks were also administered in order to examine the subjects' levels of reasoning about letters and words. In the first task participants were presented with words printed on cards (See Appendix D). The participants were told to put together those words that belonged together. After the participant grouped the words, the researcher asked how the words were grouped. The researcher then asked the participant if the words could belong together in another way. This procedure was continued until the participant had grouped the words in as many ways as he could. Results of this task were quantified by comparing each subject's method of grouping the words to those methods identified by Inhelder and Piaget (1969) in the development of part-whole reasoning. The level of graphic collections was assigned a value of 0. The non-graphic collection was assigned a value of 1. The non-graphic collection with an understanding of part-whole reasoning was assigned a value of 2. The non-graphic collection with class inclusion was assigned a value of 3. This task was also used to determine the participants' level of word recognition. The use of graphic features of words as the initial sorting criteria with no other ways of sorting recognized was assigned a value of 0 representing pre-alphabetic word reading. The use of initial- and or final-letters or letter sounds as the sorting criteria was assigned a value of 1 representing alphabetic word reading. A value of 2 representing orthographic word reading was assigned to participants who used letter clusters as the grouping criteria. Finally, participants who used meaning to sort the words were assigned a value of 3 which represents reading the words by sight.

The second researcher-created task was similar to the word task, but it involved the use of letters rather than words. A mixture of some upper- and some lower- case letters were used along with a few letters from the Greek alphabet (See Appendix E). The participant was instructed to put together those letters that belonged together. Participants were also asked if the letters could belong together in another way. The results of this task were quantified based on the levels corresponding to the type of collection. Graphic collections were assigned a value of 0. Non-graphic collections were assigned a value of 1; and non-graphic collections with part-whole reasoning were assigned a value of 2. Graphic collections with class inclusion were assigned a value of 3.

Reliability of the researcher-created tasks was addressed in the same manner as for the Piagetian tasks, that is, by a second reviewer. Agreement was 80 percent for the word task initially and 100 percent after simultaneous viewing and discussion by the two raters. Agreement was 100 percent for the letter task. Agreement on the determination of each participant's phase of word recognition through the word sorting task was 80 percent. To establish internal consistency reliability, scores from the 2 researcher-created tasks were used to calculate Cronbach's alpha (r = .697).

Procedures

Data collection consisted of the administration of the two Piagetian tasks, the two researcher-created tasks and the two subtests of the DIBELS™ assessment. All of the assessments were conducted at the school that the students attended. The Piagetian tasks and the researcher-created tasks were conducted prior to and separately from the DIBELS™ assessments. This was done in an effort to strengthen the reliability of the data by determining the developmental level based upon the participants' performance on the part-whole tasks prior to and separate from collecting the data regarding their abilities on the phonemic awareness tests. All testing was completed within a 10-day period.

Piagetian tasks were conducted individually in a conference room away from the classrooms. For the first task, the researcher showed the child 5 plastic animals, 4 dogs and 1 cat. The researcher said, "Here are 5 animals. Some of the animals are dogs," placing the dogs in a group, "and one animal is a cat," placing the cat apart from the dogs. The researcher then pointed to the dogs and asked, "Are all of these animals dogs?" Similarly, the researcher pointed to the cat and asked, "Is this animal a cat?" When the child agreed to these conditions the researcher asked, "Are there more dogs here, or more animals?" Based on the child's response the researcher asked, "Why do you say there are more (dogs or animals)? Are you sure?" This probing allowed the researcher to establish whether the child was confident or uncertain in his response. Because children can be confused by the language of the task, the researcher was prepared to continue the task by asking, “Are all the animals dogs? If you take away some of the dogs will there be any dogs left? If you take away all the dogs will there be any animals left?” This questioning was also followed with “Are you sure?”

Three types of responses were identified. The first type of response was characterized by an initial lack of understanding of part-whole reasoning. Participants at this level answered the initial question “Are there more dogs or more animals?” with the response, “more dogs” and maintained this response with further probing. This response indicated that the participant had no understanding of part-whole relationships and was quantified as 0. The next type of response was characterized by an initial response of either, “more dogs” or “more animals” that was changed after probing. This level of part-whole reasoning indicates that the participant understands the part-whole relationship in some respects, but that the concept has not yet been consolidated. Responses of this type were quantified as 1. The final response type was characterized by a correct initial response of, “more dogs” that was maintained throughout the probing. This response type indicates an understanding of part-whole relationships that has been consolidated. Responses of this nature were quantified as 2.

The second Piagetian task was conducted in a similar manner using pictures of flowers. There were 20 pictures presented in all. Four of the pictures were pink carnations. There were also 4 different colored carnations, 8 other varieties of flowers in various colors, and 4 other objects (a cardinal, a Macaw, a butterfly, and pyramids). First, the pictures were presented to the participant who was instructed to put together those pictures that belong together. The participant was asked to explain how the pictures were grouped and if they could belong together in a different way. After the participant completed the groupings, the researcher then placed the carnations in a group and the remaining flowers in a group. The researcher then questioned the participant regarding these groupings of the flowers. Questions such as, "If we make a bunch of all the carnations, will we use these pink carnations? Are there more pink carnations or more carnations? Is the group of carnations bigger, smaller or the same as the group of flowers? and If I make a group of all the flowers will there be any carnations left?" were asked in order to determine the participant's level of thinking. Again probing was used to determine the depth of the child's reasoning about the problem.

Several types of responses were identified on this task. First, the grouping portion of the task was evaluated based on the consistency of the grouping behaviors. Some participants began grouping the pictures based on a particular criterion and consequently changed that criteria as they continued the grouping process and encountered pictures that did not fit the original criterion. This kind of grouping represents a very limited level of understanding about relationships among objects in which the subject is unable to maintain focus on a single characteristic. Rather the behavior is characterized by switching criteria from one salient characteristic to another based on whatever may be most obvious to the subject in a particular picture. Also common at this level was the participants' inability to verbalize their reasoning for the grouping. Responses of this type were quantified as 0. Other participants maintained a constant criterion throughout a single grouping and placed any pictures that did not meet that criterion in a single group which they referred to as ones that did not have that particular characteristic. This level of response represents a slightly more sophisticated response than the previous one. At this level the subject is able to maintain focus on one criterion, even if some pictures do not exhibit that criterion. However, the subject is still unable to focus on multiple characteristics of a single picture in order to form subgroups within a larger, more inclusive group. Participants at this level were typically able to verbalize their reasoning for the way in which they grouped the pictures. These types of responses were quantified as 1. A third group of participants was able to form groups within the larger groupings based on multiple criteria. This level of grouping represents the most sophisticated response, and subjects who are able to do this are considered to understand the concept of class inclusion. The participants who formed groups of this type were able to verbalize their reasoning for placing subgroups within larger groups. Responses at this level were quantified as 2.

A second set of responses were also noted within this task. Some participants were not able to conceptualize any possible grouping of the pictures other than their initial method. This inability to group the pictures in another way was indicative that the participant had no understanding of part-whole relationships because of the inability to attend to any characteristics of the pictures other than the ones in the initial grouping. Some participants stated that another grouping was possible, but they could not produce it. These 2 types of responses were scored as 0. Other participants were able to produce two or more groupings of the pictures indicating their understanding that the pictures could belong to different groups based on different criteria. This response type was scored as 1. For some participants the formation of additional groups enabled them to realize that some pictures could belong with multiple groups simultaneously, a characteristic of part-whole reasoning. Responses of this type were scored as 2.

A third aspect of this task was the questioning by the researcher concerning various groupings of the flowers. These questions were aimed at determining the participants' levels of reasoning about part-whole relationships and relationships of class inclusion. Answers to the first question, "If we make a bunch of all the carnations will we use these pink carnations?" indicate whether or not the participant can consider the pink carnations as a subgroup contained within the larger group of carnations. Participants who answered yes to this question were considered to understand part-whole relationships. Those who answered no were considered to lack this understanding. The second question, "Are there more pink carnations or more carnations?" also assesses the understanding of part-whole relationships. Similarly, the remaining two questions, "Is the group of carnations bigger, smaller, or the same as the group of flowers? and If I make a group of all the flowers will there be any carnations left?" require understanding of part-whole relationships. These questions differ from those of the first task with the animals in that there are more subclasses involved. These subclasses represent a hierarchical relationship that requires a somewhat higher level of reasoning referred to as class inclusion. Participants who were able to successfully answer each of these questions were considered to understand the concept of class inclusion.

Upon completion of the Piagetian tasks, responses were quantified by assigning a value of 0 for responses that indicated no understanding of part-whole relationships, 1 for responses that showed partial understanding, and 2 for responses that showed a clear understanding.

The researcher-created tasks were conducted after the Piagetian tasks. In the first researcher-created task, the participant was given 20 cards with words printed on them (see Appendix D). The researcher instructed the participant to put together those words that belonged together. After the participant grouped the words the researcher asked for an explanation of how the words were grouped. Next, the researcher asked the participant if the words could belong together in a different way. In some cases the participant then put the words together in another way. The participants were questioned about their reasoning for each successive grouping.

Responses to this task were of three main types. Some participants grouped the words based on a particular letter, either in the initial, final, or medial position of the words. Characteristic of the first response level was a shifting of grouping criteria between these features of the words. This response was considered the most basic and was quantified as 0. Responses that maintained a focus on either the initial, final, or medial letter throughout a complete grouping were quantified as 1. A second response type was the use of letter clusters. Grouping based on word families would be an example of this level of response, which was quantified as 1 when the strategy was maintained for grouping all the words or as 0 when the strategy was not maintained. The other grouping strategy was based on syntax or semantics. This type of response included words grouped by usage or based on similar meaning, respectively. Responses of this type were quantified as 2 representing a level of reasoning that had moved beyond that of consideration of the individual parts of words to a consideration of the word as a whole along with its meaning.

This task also included the opportunity for the participants to form additional groupings. This was done in order to assess whether the participants were able to apply part-whole or class inclusion strategies to a reading related task. As with the Piagetian tasks, an inability to consider additional groupings was quantified as 0. Additional groupings, either acknowledged or realized indicated an understanding that the words could belong to different groups based on different criteria. This response type was quantified as 1. Also, some participants realized that some words could belong in multiple groups simultaneously, a characteristic of part-whole reasoning and class inclusion. This type of response was quantified as 2.

Also as a part of this task, an assessment of each participant's level of word recognition was conducted. This assessment was based on the participants' initial grouping of the words because it was believed that the initial response was the most representative of the participant's most comfortable approach to word recognition. Four response types were expected, corresponding with the four levels of word recognition. There were no participants who grouped words based on salient features of the words, which would have corresponded to pre-alphabetic reading. Therefore, the first response type that was observed was based on an initial, final, or medial letter in the word, corresponding to alphabetic reading. This level of response was quantified as 0 since this was the simplest level observed. Responses quantified as 1 were characterized by a grouping focused on letter clusters or word families, which corresponds to orthographic reading. Finally, responses that were based on syntax or meaning were thought to indicate reading based on recognition of the words by sight and were quantified as 2.

The second researcher-created task was conducted in a similar manner using cards with letters printed on them including 16 upper- and lower-case letters as well as 4 letters of the Greek alphabet (see Appendix E). Each card contained one letter. Again, additional groupings were sought and participants were questioned about their reasoning for each grouping they made.

Responses were quantified, as with the word task, based on the ability of the participants to apply the selected criterion/criteria consistently. Responses to this task included a large portion of the participants utilizing alphabetical order as a grouping strategy. This response was deemed a result of school learning rather than a level of reasoning about the characteristics of the letters. Responses of this nature were quantified as 0. Responses quantified as 1 were characterized by the inconsistent use of a single criterion. Level 2 responses were those that maintained a consistent application of a single criterion throughout a single grouping. Responses that included subgroups within a larger group were quantified as 3. Again, multiple groupings were sought and the same quantification method that was used with the word task was used for this task.

The DIBELS™ assessments were conducted individually in a conference room away from the classrooms. The Phoneme Segmentation Fluency task was administered first, followed by the Nonsense Word Fluency task.

The Phoneme Segmentation Fluency task required the student to produce the individual phonemes for words that the researcher presented orally (see Appendix A).

The Nonsense Word Fluency task required the student to read from a page of randomly ordered nonsense words comprised of vowel-consonant and consonant-vowel-consonant patterns (see Appendix B). The participants were asked to produce either the individual letter sounds or to read the entire word.

Results

In order to determine whether phonemic awareness is a developmental process it is necessary to first look at the criteria that defines a developmental process. Flavell (1963) outlines four characteristics of developmental stages. First, early behavior in the domain being examined should naturally separate itself qualitatively from later behavior in that domain. The stages should emerge in an unchanging order. That is, behaviors that are characteristic of an early stage of development should always appear prior to behaviors that are characteristic of later stages. A second characteristic of developmental stages is that structures which define behavior at earlier stages must become incorporated into the stages that follow. Thirdly, the structural properties of a stage of development must coalesce to form a system in which the properties are interdependent. Finally, a stage is characterized by an initial period in which the behavior is being formed and a final period in which the behavior is attained. An examination of phonemic awareness reveals this kind of development.

Schatschneider, Francis, Foorman, Fletcher, and Mehta (1999) identified phonemic awareness as a unidimensional construct characterized by varying levels that are dependent on age and literacy experience. Two broad levels identified by these researchers are the processes of phoneme synthesis and phoneme analysis. Phoneme synthesis, or the putting together of phonemes, is a lower level process than phoneme analysis, the taking apart of phonemes. Within these two processes there are also various levels, which Gillon (2000) identifies as developing from an awareness of larger units of words to smaller units. The delineation of these developmental levels of phonemic awareness supports the ascending difficulty of phonemic awareness tasks presented in the report of the NRP (2000).The identification of initial sounds in words is the simplest level of phonemic awareness, followed by the blending of onset-rime units and later, blending phonemes. Once individual phonemes are recognized, development of the segmenting process begins. Initially, children are able to delete a single phoneme from the beginning of a word and say the word that remains. Later an entire word can be segmented. Eventually, the ability to blend phonemes to produce nonsense words is attained (Schatschneider, Francis, Foorman, Fletcher, & Mehta, 1999). Each of these processes is qualitatively different from the others in that the child is required to attend to increasingly more detailed aspects of the word. This incremental development incorporates the abilities of each successive level and refines them to emerge at a higher level. Each stage of this development requires practice to become consistently applied at a level where it can be said that the process has been attained.

Once earlier abilities are incorporated into higher level abilities they work in conjunction with each other at the newly attained level. These developmental characteristics of phonemic awareness encourage the exploration of quantitative evidence that supports the view that phonemic awareness is a developmental process.

In order to quantitatively assess whether phonemic awareness follows a developmental progression, frequency distributions and percentages are reported for three levels of the two phonemic awareness skills, phoneme segmentation and nonsense word reading.

Phoneme Segmentation Fluency

In order to test the hypothesis that phonemic awareness follows a developmental progression a chi-square goodness-of-fit test was conducted using the frequencies for phoneme segmentation fluency and the ages of the participants as factors. In order to perform this computation it was necessary to categorize the phoneme segmentation fluency scores. Categories were developed based on the benchmark scores given for the test instrument. Phoneme segmentation fluency (PSF) scores were categorized as follows: 0 - 30 = PSF 0; 31 – 50 = PSF 1; 51 – 70 = PSF 2. The results are reported in Table 1.

Table 1

Frequencies and Percentages (in parentheses) of Three Age Groups of Children at Three Levels of Phoneme Segmentation Fluency (PSF)

Age	Phoneme Segmentation Fluency Level			Total
	PSF 0 (0-30)	PSF 1 (31-50)	PSF 2 (51-70)	
5-6	6 (15.4)	4 (10.3)	3 (7.7)	13
7-8	1 (2.6)	8 (20.5)	4 (10.3)	13
9-10	3 (7.7)	9 (23.1)	1 (2.6)	13
Total	10	21	8	39

These results indicate that the observed distribution of phoneme segmentation scores by age group is significantly different from a chance distribution. The data does in fact suggest that as age increases PSF also increases and therefore the development of PSF does fit the model of a developmental process ($\chi^2 = 11.27$, $df = 4$, $p = .024$).

The percentage of participants with PSF at level 0 was predominantly made up of 5- and 6- year-olds. Participants in the 7- and 8- year-old group as well as those in the 9- and 10- year-old group made up the greatest percentage of participants with PSF at level 1. Although participants in the 7- and 8- year-old group made up the largest percentage of participants at the PSF level 2, more 7- and 8- year-olds were at a PSF level 1 than at PSF level 2. This distribution indicates that the majority of the participants have not yet attained PSF at a level that would be considered a level 2. The observed distribution shows an increase in PSF with age from the 5- and 6- year-old group to the 7-8 year-old group. However, the 9- and 10- year-old group did not show an increased development of PSF over the 7- and 8 year-old group. This could indicate that higher levels of PSF are not necessary for transferring phonemic awareness skills to print.

Nonsense Word Fluency

A chi-square analysis was also conducted using the frequencies for nonsense word fluency (NWF) and the participants' ages as factors. Nonsense word fluency scores had to be categorized in order to perform this test. Benchmark scores provided with the test instruments were used to categorize the scores as follows: 0-30 = NWF 0; 31-50 = NWF 1; above 51 = NWF 2. Results are reported in Table 2.

These results show that the distribution of NWF scores is significantly different from a chance distribution, and that NWF increases with age. This finding suggests that NWF follows a developmental progression (χ^2 =10.395, df = 4, p = .034).

The largest percentage of participants with NWF at level 0 comes from the 5- and 6- year-old group. The majority of 7- and 8- year-olds and 9- and 10- year-olds were at NWF level 2.

Table 2

Frequencies and Percentages (in parentheses) of Three Age Groups of Children at Three Levels of Nonsense Word Fluency (NWF)

Age	Nonsense Word Fluency Level			Total
	NWF 0 (0-30)	NWF 1 (31-50)	NWF 2 (51-70)	
5-6	7 (17.9)	3 (7.7)	3 (7.7)	13
7-8	2 (5.1)	2 (5.1)	9 (23.1)	13
9-10	1 (2.6)	2 (5.1)	10 (25.6)	13
Total	10	7	22	39

Phoneme Segmentation Fluency and Nonsense Word Fluency

A comparison of the PSF levels with the NWF levels by age groups indicates that 7 – 10 year-olds have higher levels of NWF than PSF. Therefore, a contingency table was constructed with PSF and NWF as the factors. Table 3 shows the results of this analysis.

These results confirm that a significant relationship exists between the development of PSF and NWF ($\chi 2 = 12.552$, $df = 4$, $p = .014$). A contingency coefficient was also calculated ($C = .508$, $p = .014$) indicating the strength of the relationship.

This data shows that a majority of the participants are at level 1 in phoneme segmentation fluency and level 2 in nonsense word fluency. Although the data does not show a direct correspondence between the development of PSF and NWF it does show a relationship in their development. This data provides quantitative support for the assertion that both processes are in fact developmental as proposed by the criteria identified by Piaget (Flavell, 1963).

Table 3

Frequencies and Percentages (in parentheses) at Three Levels of Phoneme Segmentation Fluency (PSF) and Three Levels of Nonsense Word Fluency (NWF)

Nonsense word fluency level	Phoneme Segmentation Fluency Level			Total
	PSF 0	PSF 1	PSF 2	
NWF 0	7 (17.9)	3 (7.7)	0 (0)	10
NWF 1	1 (2.6)	5 (12.8)	1 (2.6)	7
NWF 2	2 (5.1)	13 (33.3)	7 (17.9)	22
Total	10	21	8	39

Phonemic Awareness and Part-Whole Reasoning

Further analyses were conducted to determine whether phonemic awareness develops in conjunction with part-whole reasoning. For the purposes of this study a focus on the relationships among the variables was desired over a comparison of means. For this reason regression analysis was selected rather than an analysis of variance. Quantification of the part-whole reasoning tasks resulted in scores of 0, 1, and 2 representing no understanding of part-whole relationships, an understanding of part-whole relationships that was not securely established, and an established understanding of part-whole relationships respectively. While some researchers may consider such data categorical, these scores do not represent distinct categories of a particular quantity of part-whole reasoning, rather it is understood that within each of these levels a range of scores representing varying degrees of understanding of part-whole relationships can exist. For this reason the data representing part-whole reasoning was treated as continuous.

Phoneme Segmentation Fluency (PSF)

Regression analysis was performed with PSF as the dependent variable and part-whole reasoning as the independent variable. An examination of z-scores revealed 4 outliers which were removed from the data set. Results of the regression analysis indicate that part-whole reasoning accounts for some of the variance (R^2 = .112) of PSF ($F_{1, 34}$ = 4.160, p = .049). This data shows that 11.2 percent of the variance in PSF can be accounted for by part-whole reasoning, which supports the concurrent development of the two constructs.

Nonsense Word Fluency (NWF)

A regression analysis was performed with NWF as the dependent variable and part-whole reasoning as the independent variable. An examination of *z*-scores revealed 4 outliers which were removed from the data set. Results of the regression analysis showed that part-whole reasoning accounts for some of the variance (R^2 = .272) of NWF ($F_{1, 34}$ = 12.354, p =.001). This data indicates that 27.2 percent of the variance in NWF can be accounted for by part-whole reasoning, supporting the concurrent development of NWF and part-whole reasoning.

The regression analyses show that the development of the two higher level components of phonemic awareness, PSF and NWF, are both influenced by part-whole reasoning. Based on these results, the hypothesis that phonemic awareness develops in conjunction with part-whole reasoning can be accepted.

Phonemic Awareness and Logico-Mathematical Processes

The determination of whether phonemic awareness is a logico-mathematical process requires establishing a relationship between the two phonemic awareness components, PSF and NWF, and logico-mathematical constructs. This was partially accomplished by showing the relationship between phonemic awareness and part-whole reasoning, which is a logico-mathematical process. However, in order to establish phonemic awareness as a logico-mathematical process, it is desirable to show its relationship with other logico-mathematical processes. Multiple regression analysis was conducted with PSF as the dependent variable and three logico-mathematical tasks used to determine the participants' levels of reasoning. Results are reported in Table 4.

Table 4

Standard Multiple Regression Analysis of Logico-Mathematical Constructs and Phoneme Segmentation Fluency (PSF)

Independent Variable	*B*	*SE B*	β
Part-Whole Reasoning	6.229	4.183	.237
Class Inclusion	1.167	5.639	.055
Word Sorting	9.002	5.474	.433

These results show that part-whole reasoning, class inclusion, and sorting altogether account for some of the variance (R^2 =.361) in PSF ($F_{3, 32}$ = 5.460, p =.004).

These results are significant when the contributions of all three tasks are considered together. However, the amount of variance due to each component separately is not enough to be considered significant.

Multiple regression analysis was also conducted with NWF as the dependent variable and the three logico-mathematical tasks as independent variables. Results are reported in Table 5.

Table 5

Standard Multiple Regression Analysis of Logico-Mathematical Constructs and Nonsense Word Fluency (NWF)

Independent Variable	*B*	*SE B*	β
Part-Whole Reasoning	40.422	13.549	.492*
Class Inclusion	-12.421	18.263	-.188
Word Sorting	20.730	17.729	.319

* Significant at p =.006

These results show that some of the variance (R^2 = .314) in NWF can be accounted for by part-whole reasoning, class inclusion, and sorting ($F_{3, 32}$ = 4.423, p =.011). Taken altogether these statistics corroborate Piaget's assertion that the development of each of these logico-mathematical processes is necessary but not sufficient for the development of the others. That is, their development is inextricably connected.

The results from this analysis indicate that part-whole reasoning is the only factor that is individually significant in affecting NWF although the three factors together contribute significantly.

By looking further at logico-mathematical reasoning, additional support for this quantitative analysis may be garnered. One characteristic of logico-mathematical reasoning is the process of reflecting abstraction (Piaget, 1971). This process involves, first of all, becoming cognizant of some action or operation previously unnoticed. Secondly, this action must be projected, or "reflected", to another level. In the case of phonemic awareness this means first becoming cognizant of the fact that words are comprised of individual sounds, and subsequently becoming able to utilize those individual sounds in synthesis and analysis processes. Next, the action or operation must be integrated into a new structure. In order for this integration to occur, the new structure must evolve from a preceding structure while at the same time broadening that preceding structure. That is, the process of integration causes the action or operation to become more generalized. Applied to the development of phonemic awareness, this process is illustrated by the generalization of the phoneme synthesis process from words to phonemes and then the generalization of phoneme analysis from words to phonemes.

Adams (1990) explains that children possess specific knowledge of phonemes prior to learning to read, as evidenced by their ability to understand and use oral language. This knowledge, according to Adams, is working knowledge rather than conscious knowledge. Kamii (2000) similarly explains conservation, stating that children who are unable to conserve possess the same empirical knowledge as those children who are able to conserve. The difference lies in the process of reflecting abstraction in which relationships are grouped as a whole allowing conservers to deduce conservation. In other words, their working knowledge becomes conscious knowledge through reflecting abstraction.

Summary of the Results

The questions for this study were: (a) Does phonemic awareness follow a developmental progression? (b) Does phonemic awareness develop in conjunction with part-whole reasoning? and, (c) Is the development of phonemic awareness a logico-mathematical process?

Regarding the first question, results showed significant chi-square differences in the observed frequency distributions of PSF and NWF by age groups than would be expected in a chance distribution. A contingency table further showed a significant relationship between the development of PSF and NWF. These analyses provide quantitative support for the assertions made in this study based on Piaget's theory that phonemic awareness is comprised of early behaviors that are naturally separated from later behaviors by qualitative differences, and that these stages of phonemic awareness emerge in an unchanging order; that the structures which define behavior at earlier stages are incorporated into the stages that follow; that the structural properties of each stage of development come together to form a system in which the properties are interdependent, and that a stage is characterized by an initial period in which the behavior is being formed and a final period in which the behavior is attained. Thus the hypothesis that phonemic awareness follows a developmental progression is supported both qualitatively and quantitatively.

Regarding the second question, results of regression analyses showed that significant amounts of the variance in both PSF and NWF can be accounted for by part-whole reasoning. Because PSF and NWF are components of phonemic awareness, this relationship supports the hypothesis that phonemic awareness does in fact develop in conjunction with part-whole reasoning.

Regarding the third question, standard multiple regression analysis showed that three logico-mathematical processes, sorting, part-whole reasoning, and class inclusion, contributed significantly to the development of phonemic awareness through both PSF and NWF. While the data did not show significant contributions by each logico-mathematical process separately, their combined contributions were statistically significant. This data in conjunction with the results from the other two questions in this study are sufficient to support the hypothesis that phonemic awareness is a logico-mathematical process.

Discussion

Results indicated that phonemic awareness follows a developmental progression and that it develops in conjunction with part-whole reasoning. Results are also indicative that phonemic awareness is closely linked with several logico-mathematical constructs, which supports the hypothesis that phonemic awareness is a logico-mathematical process. These findings will be interpreted in connection with existing research along with implications and limitations of the study.

Phonemic Awareness as a Developmental Process

The characteristics of a developmental process, as outlined by Piaget (Flavell, 1963), can be identified in the development of phonemic awareness. There are clear, qualitative differences in early levels of phonemic awareness that can be distinguished from later levels. Additionally, these levels of phonemic awareness can be identified in an order that does not change from child to child. While children may not experience the same levels of development at the same age, all children will experience each level in the same order. These levels of phonemic awareness can be broken into two broad categories of development. First is the identification of progressively smaller units of words, followed by the manipulation of the units in progressively smaller units (Gillon, 2004).

Identifying initial sounds in words is the most basic level of phonemic awareness. The blending of onset-rime units to form words is the next level, followed by the blending of phonemes to produce words. It is important to recognize that these processes are not associated with print at this level, but are based purely on auditory and oral recognition and production, respectively. At this point in the development of phonemic awareness there is the recognition that spoken words are comprised of individual sounds. This development occurs over time such that the child becomes aware that individual sounds can be blended together to produce words. Once this level of awareness is attained, the child is able to begin to apply it to words, first orally and then later to print. The first evidence of the application of the awareness of sounds to words is by removing the initial phoneme from a word and saying the word that remains. For example, when asked what word is left when the /c/ is removed from cat, a child at this level of development will be able to say, "at". This early ability to delete the initial phoneme in a word is followed by the ability to segment an entire word. Later development allows the child to be able to blend phonemes to produce nonsense words, which is a more abstract process because the child is producing something that is unfamiliar (Schatschneider, Francis, Foorman, Fletcher, & Mehta, 1999). This process illustrates how the child becomes increasingly aware of the more detailed aspects of words, first as a process of putting sounds together and then taking them apart.

While the observation of these processes in individual subjects over an extended period of time was beyond the scope of this study, the inclusion of a fairly wide age range allowed these characteristics to be identified. Several of the tasks used in this study made these processes evident. The sorting tasks provided insight into the participants' level of ability to attend to parts of words through print. The fact that the participants in this study were required to apply these phonemic awareness processes to print could pose a limitation in that those participants with less developed phonemic awareness would not be able to demonstrate the full extent of their development due to having to apply it in a print context. The only task that assessed pure phonemic awareness was the DIBELS phoneme segmentation task, which was presented orally and required only an oral response. Because the other measures involved the use of print, the relationships shown by the data may be somewhat less representative of the actual levels of phonemic awareness development. This would be seen in the data as a weaker relationship between phoneme segmentation fluency and the logico-mathematical constructs of part-whole reasoning and class inclusion as measured on the word task than that which was measured by the Piagetian tasks, which required no reading. This weaker relationship would then be indicative of a level of development that had not yet reached the stage of being applicable to print while the results of participants who were able to apply the processes to print would consequently demonstrate a stronger relationship between phoneme segmentation fluency and the word task.

The data, in fact, showed a significant relationship between phoneme segmentation fluency and part-whole reasoning based on the Piagetian tasks ($F_{1, 34} = 4.160$, $R^2 = .112$, $p = .049$); however, data analyses involving this relationship based on the Piagetian tasks and the word sorting task failed to indicate any significant additional contribution based on the word task alone ($B = 20.730$, $SE\ B = 17.729$, $\beta = .319$, $p = .252$). This result could be due to the fact that many of participants had not yet attained a level of development of either phonemic awareness, or part-whole reasoning, or both, that would enable them to apply these processes to print.

A second characteristic of a developmental process identified by Piaget (Flavell, 1963) is that earlier developed processes must be incorporated into those that develop later. This characteristic is seen in phonemic awareness on many levels. Children first learn to put sounds together to produce words. The recognition of these sounds, whether in clusters, as an initial sound and the remainder of the word, onset-rime units, or individual phonemes then enable the child to remove those sounds from words in progressively more complex ways (Schatschneider, Francis, Foorman, Fletcher, & Mehta, 1999).

Again, the present study was somewhat limited in that it was not feasible to observe the full range of development in single subjects. However, each of the levels of development was observed in the range of participants selected for the study. Often, the incorporation of lower level processes at the next higher level of ability can be observed as an inconsistent application of that process (Flavell, 1963). That is, before the process becomes consolidated it might be applied in some instances and not in others. This would result in a middle range score in the phoneme segmentation fluency task used in this study. The application of these less consolidated processes to print would then result in lower than expected responses on the word sorting task. Consequently, results would indicate a weaker relationship between phoneme segmentation fluency and the word sorting task. Again, the responses to the Piagetian tasks for participants at this level would be expected to show a stronger relationship with the phoneme segmentation fluency. The data analyses reflect this relationship as expected in that a multiple regression analysis showed a significant relationship between phoneme segmentation fluency and the Piagetian part-whole task (B = 40.422, $SE\ B$ = 13.549, β = .492, p = .006) while the word sorting task showed no significant contribution (B = 20.730, $SE\ B$ = 17.729, β = .319, p = .252). Eventually, incorporation of these processes allows the child to demonstrate them at a level that is commensurate with his level of understanding.

A third feature of a developmental process is that the structural properties of a particular stage of its development must come together to form a system of interdependence (Flavell, 1963). This is demonstrated most clearly when children encounter an unknown word and are able to apply phonemic awareness processes to print to read the word and then upon subsequent encounters with the word are able to recognize it. The present study illustrates this feature on the nonsense word fluency task, in which participants must utilize processes of blending phonemes at a more abstract level. Standard regression results show that higher levels of phoneme segmentation predict higher levels of nonsense word fluency ($F_{1, 37} = 10.964$, $R^2 = .229$, $p = .002$).

One unexpected result showed that for some of the older participants nonsense word fluency is demonstrated at a much higher level than phoneme segmentation fluency. Thirty-five percent of the 8 -10- year-olds ($n = 9$) demonstrated nonsense word fluency at a level significantly higher than phoneme segmentation fluency (mean difference = 93.3, range = 61-182). This occurred mostly in participants who demonstrated higher levels of development on part-whole reasoning and class inclusion on both the Piagetian tasks and the researcher-created tasks ($n = 7$). It is likely that this elevated nonsense word fluency accompanied by lower phoneme segmentation fluency is due to the fact that at some point in the development of the word recognition process when children recognize more words by sight and are able to analogize portions of new words to those of known words, awareness at the phoneme level becomes nearly obsolete and is used infrequently. This is not to say that the process of phoneme segmentation has become extinguished, rather it has become incorporated, as suggested earlier, into the higher level process of analogizing groups of letters to those contained in known words in its application to print. Once these processes have become consolidated at this level, they are more consistently applied to print in this way, thus enabling reading to become a more automatic process. Scarborough, Ehri, Olson, and Fowler (1998) obtained similar findings and hypothesized that fluent, automatic word recognition may eradicate the need to attend to and manipulate phonemes in spoken words.

Also supporting the hypothesis that phonemic awareness follows a developmental progression is the fact that separate chi-square goodness of fit tests with phoneme segmentation fluency and age as factors and nonsense word fluency and age as factors showed a distribution in which levels of phonemic awareness and nonsense word fluency were clustered by age. Although the data revealed that very few participants, even in the upper age group (2.6 percent, n = 1), had levels of phoneme segmentation between 51 and 70 phonemes per minute, further analysis showed that this is possibly due to the fact that phoneme segmentation becomes incorporated into higher level phonemic awareness processes as is characteristic of a developmental behavior. This possibility was supported by the nonsense word fluency data, which showed that 23.1 percent (n = 9) of the 7-8-year-olds and 25.6 percent (n = 10) of the 9– 10- year-olds had levels of NWF between 51-70 phonemes per minute. This disparity between levels of PSF and NWF may also be due in part to the effects of schooling on the development of phonemic awareness. At the school selected for this study, phonemic awareness instruction is a large part of kindergarten and first grade instruction. Therefore, phoneme segmentation fluency scores for children in the 5- 6- year-old group may have shown inflated scores due to the effects of this instruction.

A twofold examination of phonemic awareness in relation to the characteristics of developmental processes established by Piaget along with the analysis of frequency data for age and phoneme segmentation fluency suggest that the development of phonemic awareness is a developmental process.

Phonemic Awareness and Part-Whole Reasoning

The process of holding a word in memory and taking it apart into individual sounds is a process that requires attention to multiple pieces of information simultaneously. The subject must attend to the word as a whole while also attending to individual parts of the word. The ability to attend to part-whole relationships develops over time, becoming more refined as development proceeds. This aspect of the development of part-whole reasoning, as discussed above, is evident in the development of phonemic awareness.

In order to determine whether phonemic awareness develops in conjunction with part-whole reasoning, separate regression analyses were conducted, first with phoneme segmentation fluency as the dependent variable and part-whole reasoning as the independent variable and then with nonsense word fluency as the dependent variable and part-whole reasoning as the independent variable. Results of these analyses showed that part-whole reasoning accounts for a statistically significant portion of the variance in both constructs of phonemic awareness. Phoneme segmentation fluency was moderately correlated with part-whole reasoning ($R = .335$, $R^2 = .112$, $F_{1, 34} = 4.160$, $p = .049$), and nonsense word fluency exhibited a higher correlation ($R = .522$, $R^2 = .272$,

$F_{1, 34} = 12.354$, $p = .001$). The fact that part-whole reasoning accounts for a statistically significant portion of the variance in these two phonemic awareness components, and earlier results support the idea that phonemic awareness follows a developmental progression, suggests that the relationship between part-whole reasoning and phonemic awareness is one in which the two constructs are developing concurrently.

Inhelder and Piaget (1969) have shown that part-whole reasoning typically develops around the ages of 7-8. An examination of the data from the present study reveals that 56.4 percent ($n = 22$) of the participants who had PSF scores at level 1 or level 2, between 31 and 70 phonemes per minute, were in the 7– 8- year-old or 9– 10-year-old groups. Similarly, 48.7 ($n = 19$) percent of the participants with NWF at level 2 were in these 2 age groups. This comparison lends further support to the hypothesis that phonemic awareness develops in conjunction with part-whole reasoning.

Phonemic Awareness as a Logico-Mathematical Process

Multiple regression analysis was conducted with PSF as the dependent variable and part-whole reasoning, class inclusion, and word sorting as independent variables to examine phonemic awareness as a logico-mathematical process. Part-whole reasoning, class inclusion, and classifications such as those required by the word sorting task are processes identified by Inhelder and Piaget (1969) as logico-mathematical. Results of this data analysis showed that when all three of these logico-mathematical processes are considered together, their relationship to PSF is a significant one. However, when considered individually, the individual contributions of each process are not significant.

Multiple regression analysis was also conducted with NWF as the dependent variable and the three logico-mathematical tasks, part-whole reasoning, class inclusion, and word sorting, as the independent variables. This analysis showed a significant combined contribution of the three logico-mathematical processes to the development of NWF (R^2 = .314, p =.011). Additionally, in this analysis part-whole reasoning was found to have a significant contribution independently (β = .492, p =.006). A surprising finding in this analysis was a negative, though not statistically significant contribution of class inclusion (β = -.188, p = .502).

Though it is doubtful that the development of class inclusion could adversely affect phonemic awareness, it is possible that this finding is due to the fact that class inclusion is a higher level logico-mathematical process than part-whole reasoning and classification, and therefore, participants who have attained a level of logico-mathematical reasoning that includes class inclusion are likely to be older and consequently belong to that group of participants who have consolidated phoneme segmentation into more complex processes in its application to print. However, it would be expected that this group of participants would also have higher levels of NWF. An examination of the data showed that only 17.9 percent (n = 7) of the participants had fully attained class inclusion. All of these participants had NWF scores above 51. Also, 60.8 percent (n = 14) of the participants with NWF scores above 51 phonemes per minute had class inclusion scores of 1. All of these participants were in the 7-8- year-old and 9-10-year-old groups. This data supports the idea that those participants who had developed some understanding of class inclusion, likely belonged to that group for whom phoneme segmentation had been incorporated into higher level processes in its application to print.

The logico-mathematical processes of part-whole reasoning, class inclusion, and classification develop in conjunction with each other such that, the development of one serves to advance the development of the others. That is, the development of one is necessary but not sufficient to promote development of the others. This factor may explain the lack of individual significance of the processes in the data analysis and therefore support the hypothesis that phonemic awareness is itself a logico-mathematical process. It follows, that the development of phonemic awareness would then support the development of part-whole reasoning in a reciprocal manner.

Limitations of the Study

Certainly this study is limited by the fact that it did not study individual development over a period of time. This has been an obstacle to the study of developmental processes for some time. However, with the results of the present study perhaps sufficient evidence has been given to demonstrate the need for a more thorough investigation that might include longitudinal data.

Another obvious limitation is the lack of a group of 3- 4- year-olds. Such a group would provide insight into the development of phonemic awareness as a developmental process in conjunction with part-whole reasoning, prior to the intervention of schooling.

The fact that this study addressed only phoneme segmentation and blending was also a limiting factor. With only these two upper-level components of phonemic awareness as the focus, it is likely that the results may actually underestimate the relationships that exist between part-whole reasoning and phonemic awareness. However, the present study was aimed specifically at the link between phonemic awareness and beginning reading when those processes are being applied to print. Therefore, the selection of these upper-level components was necessary.

Additionally, the sample selected for this study was comprised of a predominantly low socioeconomic population. Results for a more economically diverse sample would likely differ from those of the present study.

Implications

Even with these limitations, the present study resulted in outcomes that warrant further investigation. The present findings, which suggest that phonemic awareness follows a developmental progression that parallels that of part-whole reasoning, could lead to improved instruction that is aimed at developing phonemic awareness as a construct rather than training children to identify sounds in words by rote memorization. It is believed that children who are able to apply phonemic awareness processes to reading with a conceptual understanding will develop more meaningful reading habits. Conversely, it is believed that children who are taught to apply phonemic awareness processes to reading without a conceptual understanding, though they will learn to decode words and be able to read, may not engage in meaningful reading experiences that are necessary as they move into upper elementary grades.

The finding, in this study, that phonemic awareness appeared to diminish as reading ability increases also provides support for current research that has led to an emphasis on phonemic awareness instruction in the early grades. Apparently, its importance in the process of learning to read may be limited to a crucial period that must be considered in relation to the development of individual children.

With the understanding that part-whole reasoning is necessary but not sufficient for the development of phonemic awareness, perhaps educational experiences in which children in the preschool and early elementary grades are encouraged to reason about the relationships between and among objects, including letters and words, in their world will be viewed as important to the development of phonemic awareness. Perhaps a focus on this aspect of development would facilitate phonemic awareness instruction that is more conducive to its development as a construct.

Suggestions for Further Study

Further study is needed concerning the development of phonemic awareness and its relationship to part-whole reasoning. Experimental studies need to be conducted in which subjects receive phonemic awareness instruction along with activities that encourage the exploration of relationships between objects including letters and sounds. Such an experimental group could then be compared with subjects who receive typical phonemic awareness instruction that is limited to the component processes of phonemic awareness.

Further study is also needed to investigate the way that phonemic awareness processes are utilized as reading becomes a more automatic process and is applied to print. Studies of this nature could provide insight for improving reading instruction beyond the early elementary level.

Research has shown that the relationship between phonemic awareness and word reading is reciprocal in nature (Mann, 1987). Whereas phonemic awareness improves word reading ability, word reading ability also improves phonemic awareness. Also, studies have suggested that 20 hours of phonemic awareness instruction throughout the school year is sufficient for most kindergarten and first grade children. Considered along with the findings from the present study that PSF at level 1 had the greatest impact on both NWF and phase of word recognition, investigations that propose to identify a level of phonemic awareness that is sufficient to support the application of phonemic awareness processes to print may be warranted.

An important insight from this investigation was the role that schooling plays in contributing to participants' responses. Results of the letter task that was designed for this study to assess participants' levels of part-whole reasoning in relationship to print were not utilized in the data analysis because a majority of the participants, 55 percent (n = 21), were limited in their classification of letters to placing them in alphabetical order. It was believed that this classification was the result of an emphasis on instruction in alphabetical order. Perhaps further study that investigates different instructional approaches to learning about the alphabet could provide additional insight into beginning reading instruction. Also, studies which investigate the possibility that a heavy emphasis on alphabetical order could constrain the development of conceptual knowledge about print that is necessary for proficient reading may be explored.

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Appendix A

Phoneme Segmentation Task

<u>Progress Monitoring 1</u>

Phoneme Segmentation Fluency

leaned	/l/ /ea/ /n/ /d/	shine	/sh/ /ie/ /n/	____/7
worm	/w/ /ir/ /m/	smiled	/s/ /m/ /ie/ /l/ /d/	____/8
porch	/p/ /or/ /ch/	creek	/k/ /r/ /ea/ /k/	____/7
grabbed	/g/ /r/ /a/ /b/ /d/	bags	/b/ /a/ /g/ /z/	____/9
lit	/l/ /i/ /t/	kissed	/k/ /i/ /s/ /t/	____/7
get	/g/ /e/ /t/	pouch	/p/ /ow/ /ch/	____/6
roared	/r/ /or/ /d/	whale	/w/ /ai/ /l/	____/6
broke	/b/ /r/ /oa/ /k/	meet	/m/ /ea/ /t/	____/7
raise	/r/ /ai/ /z/	note	/n/ /oa/ /t/	____/6
worth	/w/ /ir/ /th/	points	/p/ /oi/ /n/ /t/ /s/	____/8
that	/TH/ /a/ /t/	cold	/k/ /oa/ /l/ /d/	____/7
worked	/w/ /ir/ /k/ /t/	fight	/f/ /ie/ /t/	____/7

Total: ____

Error Pattern:

Appendix B

Nonsense Word Fluency Task

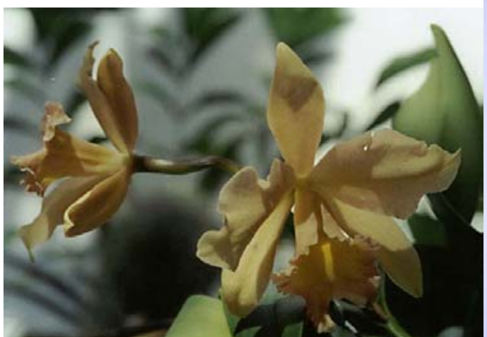
Progress Monitoring 7 – Nonsense Word Fluency

paj	tel	fal	tef	jut
sen	jit	noc	ig	kil
bos	hav	hiz	zut	kom
ak	sas	wem	wez	daj
el	puv	sef	fob	liz
es	suf	yof	fen	jag
uf	et	pes	foj	sut
nuz	puj	pur	uz	mok
un	kun	wej	en	vit
lob	pid	yot	wen	ip

Appendix C

Pictures for Piagetian Task








Appendix D

Word List for Researcher Created Task

sad	hill	thing
sat	nook	truck
bit	book	might
bad	bake	
bat	rack	
cob	took	
can	look	
cat	bend	
hug	bite	
had	bait	
hat		

Appendix E

Alphabet List for Researcher Created Task

A a a	θ
B b	Ω
d	δ
E e	Σ
F	Δ
G g g	
N	
Q q	